



# NASA ASTROBIOLOGY INSTITUTE ANNUAL REPORT YEAR [July 2002 - June 2003]



Focus Groups: Evogenomics

<b>Focus Group:</b>	<b><i>Evogenomics</i></b>
<b>Project Title:</b>	<b><i>Evolutionary Genomics Focus Group</i></b>
<b>Chairs:</b>	<b><i>S. Blair Hedges , James Lake</i></b> <a href="#">[view project member list]</a>

## Project Progress

### **Progress Report for the Evolutionary Genomics Focus Group 2002–2003**

Blair Hedges and James Lake, Co–chairs

#### **Progress report for Year 5**

The purpose of the Evolutionary Genomics Focus Group (EvoGenomics) is to coordinate, combine, and enhance research efforts involving evolutionary genomics across the multiple disciplines and institutions represented in the astrobiology community. EvoGenomics is a unique collaboration of astrobiologists combining expertise in molecular evolutionary analysis, organic chemistry and biochemistry, Earth history, and paleontology.

This last year has been extremely productive for EvoGenomics. More than 30 papers have been published, or are in press, by the laboratories of the focus group. Many of these articles have been published in high profile journals such as *Science*, *Nature*, and *Proc. Nat. Acad. Sci.*

Broadly speaking, the focus group emphasizes three areas of enquiry. These are: the evolution of gene function, the evolution of multicellular animals and of eukaryotes, and horizontal gene transfer and prokaryotic evolution. Major discoveries in these three areas are described below.

#### **Research Discoveries**

**The Evolution of gene function.** Outstanding work has been performed by the Benner group, University of Florida, in the area of synthetic biology. First they have developed new tools to correlate events in the genomic record with the paleontological and geological records. These include tools to date gene duplications, identify pathways, and reconstruct ancestral proteins from extinct organisms to test hypotheses. For example, they have correlated the emergence of fermentation in yeast with the emergence of fermentable fruits in angiosperms. Work from their lab, and elsewhere, has been summarized in two important reviews (Benner, S.A., *Science* 297, 1121, 2002; Benner, S. A. *Nature* 421, 118, 2003).

In collaboration between UCLA and Penn State University, House (PSU), Runnegar (UCLA), and Fitz-Gibbon (UCLA) have related the geobiological record to the tree of life, using whole genome-based trees. The study involved a genomic tree of 52 prokaryotes and will appear soon in *Geobiology* (in press).

In the Lake lab, Anne Simonson and Jim Lake (UCLA) proposed a mechanism for protein synthesis based on atomic resolution ribosomal structures (Simonson Lake, *Nature*, 2002). This mechanism is extremely significant for the evolution of protein synthesis because ribonucleic acid (RNA) molecules, rather than proteins, are the essential components of the mechanism. Hence it suggests how today's RNA/Protein world may have started from a RNA world, and thereby potentially answers a chicken or egg type question, in this case suggesting that RNA was first.

**The evolution of multicellular animals and of eukaryotes.** David Jacobs' group, UCLA, has continued to be extremely productive in relating developmental genetics to early animal evolution. His group has made significant advances in deciphering the origin of sensory structures; in proposing terminal addition as the primitive mode of development in the bilateral animals; in analyzing potential homologies in bilateral animal skeleton building; and in carefully analyzing import issues relating to using protein clocks to date the metazoan radiation.

Blair Hedges' group (Penn State University) has been extremely productive, and has published several studies involving evolutionary relationships, and the timing of the radiation of multicellular life using large numbers of genes. In ongoing work, his analyses predict an early origin for multicellular much earlier than so far shown by the fossil record (Hedges et al., in preparation). He also published significant reviews (Hedges, *Nature Rev. Gen.*, 2002; Hedges Kumar, *Trends in Gen.*, 2003).

**Horizontal gene transfer and prokaryotic evolution.** In collaboration between the Riley laboratory (Woods Hole) and the Lake lab (UCLA), the search to find genes that are subject to more frequent horizontal gene transfer (HGT) continues. In preliminary studies we are finding that there are several discriminating factors that influence the frequency of HGT.

In a separate study, the Lake lab has found that HGT has potentially accelerated bacterial genome innovation and evolution. In particular, a large whole genome analysis indicated that new genes are being introduced into bacterial groups 10,000 times faster than possible without HGT (Jain, Rivera, Moore, Lake, *Mol. Bio. Evol.*, in press).

### **Education/Public Outreach.**

EvoGenomics has been active in public outreach this last year. Hedges received a National Science Foundation (NSF) grant to establish a three-year summer training program in astrobiology for undergraduates. Approximately 10 students will be admitted each year from colleges and universities other than Penn State. The Benner group has been active in several initiatives,

namely the NASA-to-National Institutes of Health (NIH), the NASA-to-Department of Defense (DoD), and the NASA-to-Department of Energy (DoE) initiatives. These initiatives are bringing the topics that NASA supports within its purview to these other agencies. This approach appears to be highly effective. The Lake group hosted Prof. Todd Gary (Tennessee State University) during the summer of 2002. The results were extremely successful, and the sabbatical helped strengthen the professional and personal links between a large minority feeder institution and Astrobiology. Their experiences were communicated with other faculty at the annual Astrobiology meeting in Phoenix in February 2003. Dr. Maria Rivera (UCLA) frequently lectured to faculty and undergraduates from predominately minority institutions, explaining her research and the opportunities and excitement of EvoGenomics. Lectures were given at the Minority Institutions Astrobiology Collaborative Meeting, NASA Goddard Space Flight Center, Greenbelt, Maryland, in September 2002; at the Mexican American Engineering and Science Society Annual Meeting in Anaheim, California, in October 2002; and at NASA Week at Bennett College in Greensboro, North Carolina, in March 2003.

For EvoGenomics  
Jim Lake, Professor UCLA

[Focus Group Description & Activities](#)